DOCUMENT RESUME

ED 295 762 RC 016 564

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TITLE Investment in Education as a Rural Development Strategy: Do Increased Inputs Have an Impact?
PUB DATE Feb 88
NOTE 18p.; Paper presented at the Annual Meeting of the Southern Association of Agricultural Scientists (85th, New Orleans, LA, January 31-February 3, 1988).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Educational Assessment; *Educational Economics; Educational Finance; Elementary Secondary Education; *Input Output Analysis; *Models; *Productivity; Resource Allocation; *Rural Development; *Rural Education

ABSTRACT

Support for public education wavers in a number of states due to a lack of evidence indicating that increased funding is associated with increases in output. Maintaining and increasing this support, however, is critical for rural communities as they seek to strengthen their human capital base as a strategy for economic growth and development. The results of an education production model, estimated with an expenditure variable specified as a polynomial lag, suggest allocating resources to education increases output as teacher quality and quantity and increased funding have positive influence on educational outcomes. Standardized achievement test scores are used as school output measures. Teacher input measures include percent with masters degrees and pupil/teacher ratio. Per pupil expenditure is used as a measure for supplies/facilities. Nonschool inputs are average daily school system attendance rate and parent-teacher organization participation rate. Percent of population 25 years or older with high school diploma and percent nonwhite are included as household or socioeconomic input measures. The high school student retention rate represents school quantity. Classifications of school districts (city, urban county, suburban county, and rural county) are included in the model using discrete measures to examine the effects of community structure on the education process. (NEC)

FS88-10

February 1988

INVESTMENT IN EDUCATION AS A RURAL DEVELOPMENT STRATEGY: DO INCREASED INPUTS HAVE AN IMPACT?

by

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Abstract

Support for public education wavers in a number of states in the U.S. due to a lack of evidence indicating that increased funding is associated with increases in output. Maintaining and increasing this support, however, is critical for rural communities as they seek to strengthen their human capital base as a strategy for economic growth and development. This paper reports the results of an education production model estimated with an expenditure variable specified as a polynomial lag. The results suggest allocating resources to education increases output as teacher quality and quantity and increased funding have positive influence on educational outcomes.

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DO INCREASED INPUTS HAVE AN IMPACT?

Introduction

The increased emphasis on education's importance in the economic development of the South Half Way Home and a Long Way to Go and Shadows in the Sunbelt, Babb and Long, has corresponded with initiatives by legislatures in several southern states to increase funding for public education (Arkansas, Georgia, North Carolina, Mississippi, Tennessee, and Virginia). Despite the generally recognized economic and social benefits from education investments, measurable results of improved school output from increased funding is lacking. Some southern legislators have suggested cuts in state funding for education because of the lack of increased levels of school achievement (Atlanta Constitution).

This paper reports new evidence on the relationship between inputs and outputs in the education process. The first section of the paper presents a theoretical model for education production. The next section discusses specification of an empirical model. The third section presents and discusses the results of the estimation. Conclusions are then presented.

An Education Production Model

Estimating the relationship between education production inputs and outputs has been the focus of several studies attempting to gain insight into issues concerning resource allocation in the school system. Most of the studies (Coleman, Burkhead, Hanushek, Katzman, Kiesling, Levin and Bowles, Perl, Summers and Wolfe) have used a production function framework to focus on the influences of various school supplied inputs on some measure of education outputs. Two studies (Leibowitz; Murnane, Maynard and Ohls) used a production model to analyze the relationship between household inputs and achievement, as measured by standardized achievement test scores. The presents the results. Conclusions and policy implications are then discussed.

Theoretical and Empirical Models for Education Production

Estimating the relationship between education inputs and school outputs was the focus of several studies attempting to gain insight into school resource allocation. Most of these studies (Coleman, Burkhead, Hanushek, Katzman, Kiesling, Levin and Bowles, Perl, Summers and Wolfe) used a production function framework to analyze the influences of various school supplied inputs on education outputs. Two studies (Leibowitz; Murnane, Maynard and Ohls) employed a production model to analyze the relationship between household inputs and educational output, as measured by standardized achievement scores. The education production function model presented in the economics literature (Burkhead, Hanushek, Katzman) is generally of the nature,

$O = O(S,F,P,I).$

The output vector, O, includes a variety of desired outcomes of a multiple-objective school system. The school input vector, S, includes capital and labor inputs supplied by the school system. F is a vector of household time and purchased goods allocated to education production. The other two input vectors, (P and I), represent student and peer inputs to education.

This study views education as a production process in which decisions result from a public process that establishes the community's objective function for education. The school system is directed to achieve the community's desired mix of education outputs responsive to state and federal mandates and to community demand. School administrators attempt to achieve this minimum output level for each student and have little flexibility when making production decisions that would allow trade-offs between the various outputs the school is producing, regardless of changes in input costs, input flows, or technology changes. Administrators are constrained in their ability to substitute inputs because of salary structures, staff-tenure systems, state-mandated input levels and other policy decisions that are not under their control.

School officials, however, have limited understanding of specific school outputs demanded or how to measure many of the outputs such as citizenship, motivation, attitude. There simply has not been adequate research to provide a very complete theoretical understanding of the technical relationships of education production. And, while school administrators have some control over the allocation of the resources in the vector of school inputs, S, they have only limited influence over other input vectors. So, the effects of controllable inputs are constantly being influenced by community and family factors that are beyond the school's control.

Output Measure

Standardized achievement test scores are used as school output measures in this study. While these variables are limited as representative measures for total school output (Levin), there are strong representative measure for cognitive skills produced by the school system. The standardized score does not capture the whole of education quality, but it represents a large enough portion of the quality dimension of education to be of great use to policy makers (Kiesling). Eighth grade math (M8) and reading scores (R8) are used as school output measures in this study.

School Input Measures

Teacher or labor measures that have been statistically significant in prior production studies include teacher experience (Hanushek, Katzman, and Summer and Wolfe), teacher education achievement and training (Hanushek, Katzman, and Summer and Wolfe), teacher/pupil ratio (Katzman) and starting teacher salary (Perl). Broader school input measures also have been used. Per pupil expenditures on materials and supplies (Burkhead), per pupil number of school library books (Summer and Wolfe), school-building age (Burkhead, Katzman), school system average daily membership (Burkhead, Katzman, Kiesling), and class size (Katzman; Summer and Wolfe) are other measures that have been significantly associated with standardized achievement test scores in prior research. While many of these variables are intuitively related to economic concepts of labor and capital inputs of education production, education theory was not presented in support of the inclusion.

Two measures are used in this study as teacher input measures, the percent of teachers with masters degrees (MSD) and the pupil/teacher ratio (PTR). These measures are linked to Virginia's Standards of Quality, prior research, the economic concept of labor, and human capital theory (Schultz). Investment in graduate education is expected to increase the quality of the labor input and is hypothesized to be directly related to education output.

The pupil/teacher ratio (PTR) is a measure of the relative number of teacher inputs in a school district. Districts with lower PTR have a higher level quantity of teacher input. These localities should have a higher rate of education output other things being even. Since decreases in PTR reflect relatively greater numbers of teachers in a school (i.e., higher teachers per pupil), PTR is hypothesized to be inversely related to education output.

Per pupil expenditure (TPP) is used as a measure for supplies and facilities. Since economic theory suggests that the higher the inputs, over reasonable ranges, the greater the production output, the variable is hypothesized to have to be positively associated with output. The measure was significant and directly associated with education output as measured by achievement test scores in Perl's research. Keisling and Katzman also used a per pupil expenditure measure, but found it to be nonsignificant or negative in their studies.

Nonschool Inputs

Several measures are used in this study to represent nonschool inputs whose importance was emphasized by Katzman. A measure of the average daily school system attendance rate is included as a proxy for student's time input into schooling. This measure, ATTEND, is expected to be correlated with students' attitude, motivation, and health and is hypothesized to have a positive relationship to output.

The parent-teacher organization (PTO) participation rate (PTOR) was included in the model to test the hypothesis that volunteer inputs through PTO have a positive influence on education outcomes. This variable is specified as the parent-teacher organization membership divided by total student enrollment. Virginia schools do not document volunteerism, and the parent-teacher organizations have no systematic records other than membership. Hence, the PTOR variable should be recognized as a weak measure for volunteer input. It is hypothesized to be positively related to education output.

Two variables included in the model as household or socioeconomic input measures were the percent of the population 25 or older with a high school diploma (GRADS80) and the percent of the population that is nonwhite (PCRACE). GRADS80 is hypothesized to have a positive relationship to output, while PCRACE is hypothesized to be negatively related.

The measure chosen to represent school quantity was the high school student retention rate (HOLD). This variable is included to measure the effect of retaining students in school on the average school system achievement level. This measure is hypothesized to be negatively associated with the school quantity output measure.

Four classifications of school districts, city, urban county, suburban county, and rural county, were included in the model using discrete measures (i.e., dummy variables) to examine the effects of community structure on the education production.

Data and Procedures

Cross-sectional data for 113 Virginia school districts were used in the study. The school district is the unit of observation. Virginia school districts have the same boundaries as counties and independent cities. A polynomial lag was specified for the total per-pupil-expenditure measure and included in the model.[1] The general lag specification is,

$$Y = \alpha + \beta(w_0 X_t + w_1 X_{t-1} + \ldots + w_n X_{t-n}) + \Sigma\beta_j Z_j + \varepsilon$$

assuming,

$$w_j = S_0 + S_1 i + S_2 i^2, \text{ where } i = 0,1,2,3,\ldots,n.$$

where Y is the output measure, X_{t-n} are the lagged values of per pupil expenditures, and Z_j are the other independent variables in the model, and w_i is the lag weight for the ith year reflecting the effect of expenditures on output over time. The model assumes that the lag weights can be specified by a continuous function that can be approximated by evaluating a polynomial function at discrete points (Pendyck and Rubinfeld).

Substituting the w_i equations for a second order, four year lag into the original equation,

$$Y = \alpha + \beta S_0 X_t + \beta(S_0 + S_1 + S_2)X_{t-1} + \ldots$$
$$+\beta(S_0 + 4S_1 + 16S_2)X_{t-4} + Z_j + \varepsilon$$

1The results for the current expenditure variables in estimated models indicated that current expenditures were inversely associated with the achievement test scores used as dependent variables.

Combining terms yields the estimating equation,

$$Y = \alpha + \beta c_0(X_t + X_{t-1} X_{t-2} + X_{t-3} + X_{t-4})$$

$$+ \beta c_1(X_{t-1} + 2X_{t-2} + 3X_{t-3} + 4X_{t-4})$$

$$+ \beta c_2(X_{t-1} + 4X_{t-3} + 9X_{t-3} + 16X_{t-4}) + Z_j + \varepsilon$$

The models were estimated with the ordinary least square procedure. The lagged expenditure amounts are adjusted for inflation to 1983 real dollars with the Consumer Price Index. Several formulations of the polynomial lag structure were estimated. The second-order, four-year lag presented the best fit, and is used in the models reported below.

The inclusion of the polynomial lag structure introduces lagged values of variables from the cross-sectional data set, introducing the possibility of heteroscedasticity. Generalized Park-Glejser Tests were performed revealing no problems associated with heteroscedasticity. The models also were examined for multicollinearity. Variance inflation factors (VIF) and condition indices (CI) suggested no collinearity problems. The only VIFs and CIs greater than 6 and 9, respectively were associated with the lagged expenditure measures.

Estimation Results

The two estimated models are presented in Table 1. One had a reading achievement score as the dependent variable, the other a math score.

The reading model had an R^2 of .74 and four significant variables plus the three structural factors for the polynomial lag. PTR, GRADS80, and PCRACE all had the hypothesized signs. HOLD had a significant positive sign, the opposite of the hypothesis. The other variables (MSD, ATTEND, PTCR, R1, R2, R3) were not statistically significant.

Table 1: OLS Regression Results for Education Production Models[1]

Variable	Reading Production Model	Math Production Model
INTERCEPT	-36.7554	61.4390
	(-.568)	(-.934)
HOLD	.9481**	.6244
	(1.989)	(1.289)
PTR	-.8824***	-.5246
	(-1.483)	(-.867)
MSD	-.0126	.1814**
	(-.143)	(2.023)
ATTEND	-.0475	.5466
	(-.061)	(.693)
PTOR	3.2520	.9781
	(.776)	(.693)
GRADS80	.4784*	.4760*
	(6.888)	(6.744)
PCRACE	-.2479*	-.1238*
	(-6.781)	(-3.333)
S1	-.0133*	-.0273*
	(-2.475)	(-5.010)
S2	.0167*	.0343*
	(2.484)	(5.011)
S3	-.0034*	-.0069*
	(-2.504)	(-4.993)
R1	3.4356	3.9867***
	(1.334)	(1.523)
R2	1.7642	1.5983
	(.714)	(.637)
R3	-.0970	-.3089
	(-.349)	(-.110)
R Square	.7403	.6757

[1]t statistic in parentheses
*significant at the .01 level
**significant at the .05 level
***significant at the .15 level

The math model had an R^2 of .68 and seven statistically significant variables, MSD, GRADS80, PCRACE, R1, and the polynomial lag structural factors. All variables had the hypothesized signs.

The lag structures for the two models were computed by substituting the structural factors (S1, S2, S3) into the weight formula. The results are presented in Table 2. Tests for statistical significance indicate a strong lag relationship. Current year expenditures are negatively associated with schooling outcomes (Figure 1). The lagged effect then follows an inverted U pattern with a peak at W_2.

The regression results for both education production models, reading and math, provide general support for the hypotheses that school and household inputs influence educational outcomes. The signs for the socioeconomic measures, GRADS80 and PCRACE are generally consistent with expectation and are statistically significant in both models. These results are consistent with earlier research and support hypotheses about the importance of household factors in educational production.

The teacher quantity (PTR) and quality (MSD) variables are each significant in one model. A lower pupil/teacher ratio is associated with higher reading achievement. A higher percent of teachers with graduate degrees is associated with higher math achievement test scores.

The significance of the polynomial lag structure for per pupil expenditures supports the hypothesis that increased school funding is associated with increased reading and math achievement test scores. The lag weights, Figure 1, illustrate that a time lapse is required before increased expenditure levels are associated with increases in achievement test scores. The lag structure begins with a negative relationship, increases for two years, and then declines to approach zero after four years.

Table 2: Polynomial Lag Weights for the Expenditure Variable[1]

Weight	Reading Model	Math Model
w0	-.013287* (-2.475)	-.027321* (-5.010)
w1	.0000181 (.733)	.0000338 (1.49[illegible]
w2	.027143* (10.331)	.013428* (5.030)
w3	.005953* (2.346)	.012618* (4.988)
w4	-.001417 (-1.433)	-.001665** (-1.660)

[1]t statistic in parenthesis
*significant at the .01 level
**significant at the .10 level

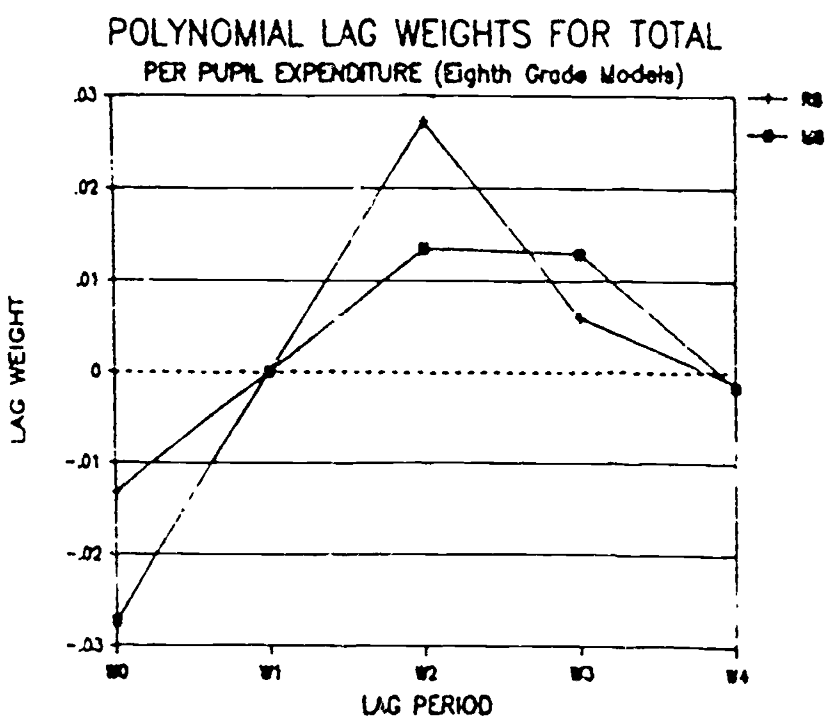

FIGURE 1. EIGHTH GRADE EXPENDITURE LAGS

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The expenditures results are of particular interest. Earlier studies (Perl, Katzman) have not shown expenditures to be positively associated with school outcomes as measured by achievement scores. Specifying the expenditures in a polynomial lag, however, indicates that the impact of the increased spending is not evident in the output measure with two years later. Perl and Katzman's failure to specify a lagged relationship may explain their counter intuitive results.

Comparing relative changes associated with lag weights of the polynomial lag for the per-pupil-expenditure measure across models is difficult because of the differences in the values of the dependent variables. Converting the weights to elasticities, however, changes the regression coefficients to unit-free percentages of change in the dependent variable associated with percentage changes in the independent variable and allows for comparison of the effects across models. Elasticities are defined,

$$E_j = \beta_j \frac{X_j}{\bar{Y}} = \frac{\frac{\partial Y}{\bar{Y}}}{\frac{\partial X}{\bar{X}}}$$

where E_j is the elasticity of the jth variable, β_j is the regression coefficient of the jth variable, Y is the mean value of the dependent variable, and X is the mean value for the independent variable. Elasticities are computed by multiplying the regression coefficient times the mean input value divided by the mean output value. An elasticity is interpreted as the percentage change in the dependent variable associated with a one percent change in the independent variable.

The elasticities for the polynomial lag weights of per pupil expenditures in the education production models are presented in Table 3. The impact of a ten percent change in expenditures on achievement test scores also is

Table 3: Elasticities for Per Pupil Expenditure Weights and Effects of 10% Change in Expenditures on Achievement Test Scores

Model	Elasticities R*8	Elasticities M*8	Effects of 10% Change in Expenditures R8	Effects of 10% Change in Expenditures M8
w0	-.6965	-1.1650		
w1	.0009	.0014	.004	.004
w2	1.5146	.6096	7.529**	3.720**
w3	.3026	.5318	1.502**	3.245**
w4	-.0672	-.0643	-.334**	-.394**
		Total Effect***	8.697	6.571

*R is reading achievement
M is math achievement
**Change associated with lag significant at .1 level
***Total includes only changes that are associated with significant variables.

presented in Table 3. These results indicate that increases in achievement test scores are associated with increases in expenditures. A ten percent increase in per pupil expenditure is $260. It is associated with a reading score increase of 8.697 and a math score increase of 6.571. These scores are on a 100 point scale and appear to be relatively large shifts.

Conclusions

The results of the education production models discussed above provide several findings that have important implications for education policy. The results indicate the association of specific variables with achievement test scores. While the model does not show causality, the relationships identified are interpreted as suggesting causality for policy implications. The results are:

1. Expenditures on education have an impact on cognitive learning skills. An increase in spending on education is associated with a lagged positive impact on education production. The estimates in this study are based on general increases in expenditures. Targeting expenditures to items that would not require capital investments (i.e., PTR, MSD) could greatly increase the marginal impact of additional funding.
2. Teacher quality and quantity are important factors in the production of cognitive skills. Quality is associated with higher math scores and quantity is associated with higher reading scores.
3. Improving achievement test scores by increasing the level of school inputs requires a lag period. The empirical results of the polynomial lag for the per pupil expenditure variable clearly indicate that a lag period is needed before the impacts of the increased spending are realized through increased output.

4. Household factors clearly are important in the education production process. The adult education level in the community is positively associated with both achievement test measures. The percent of nonwhite population, a measure representing differences in income levels and the effects of historic barriers to employment and education faced by the nonwhite population, is negatively associated with both. Additional research is needed to determine which factors associated with an educated population and a lower nonwhite population are associated with achievement test scores.

The results indicate the importance of both school and household inputs in education production. Clearly, community policies to increase the level of education output should consider the education system as a production process that utilizes inputs from a variety of input sectors. While recognizing the value of school inputs, research should be directed at identifying specific household, volunteer, and community factors that are positively associated with education output.

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